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hypothesis, he shows, very ingeniously, that the discordance between his results and mine may be almost wholly removed. It may, therefore, be desirable that I should state, that my method has been in this respect misapprehended, and that *no diminution of the pupil* was employed in my telescopic determinations of magnitudes. The discordance of our results remains, therefore, to be accounted for.

It has also been supposed (see p. 17 of the Appendix), that the apertures employed by me in the determination of magnitudes, by reducing the light of the stars to a minimum, are not given in my paper above alluded to; and that they must have been different from those contained in the table on p. 191 of the *Monthly Notices.* The apertures there stated, however, are those which I actually employed, as being *suitable to my own eye*, which requires an aperture of $0^{\text{in}}\cdot15$ to render visible Argelander's average sixth magnitude. The minimum visibility of a star with any one of the apertures in that table *determines* it to be of the magnitude corresponding to that aperture, and standing against it in col. 1. The heading of that column ("Σ's magnitudes") does not indicate that the numerical magnitudes composing it were *actually assigned by Struve to any particular stars observed and estimated by him*, but only that those magnitudes are arranged according to the ratio of progression employed by Struve and adopted by myself; as those in col. 2 represent the *theoretical* scale adopted by Sir John Herschel. In fact, the magnitudes in col. 1 are carried down to the 15th, and in col. 2 to the 24th; whereas Struve never estimated magnitudes below the 12th, nor Herschel below the 20th.

Remarks on the Application of the Heliometer to the Photometry of the Stars. By Manuel J. Johnson, Esq., Director of the Radcliffe Observatory, Oxford. (Appendix I. to vol. xii. of the Radcliffe Observations).

Before proceeding to give an account of his researches on this subject, Mr. Johnson explains a mode of estimating the magnitudes of the stars, which was practised by himself and his assistant Mr. Lucas, while engaged in reobserving the objects of Groombridge's Catalogue with the meridian instruments. This was founded on the degree of illumination which was necessary for the observation of the star, if under the sixth magnitude, and in the case of larger stars, on the visibility of the *corona* or halo of light by which the object was observed to be surrounded. In this manner he was enabled to form an unbroken scale of brightness, extending from stars of the fourth down to those of the tenth magnitude, the latter being the smallest stars visible in the transit telescope when the field of view was slightly illuminated. A very satisfactory accordance was found by Mr. Johnson to subsist between his own results and those of his assistant; and after some experience of the method he felt convinced that a tolerably accurate judgment of the relative brightness of the stars might be formed by employing it.

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Subsequently, the observations with the heliometer suggested to Mr. Johnson the possibility of obtaining a photometric definition of his scale. In measuring the distance between two stars of unequal magnitude, it becomes necessary to reduce the aperture of one of the segments of the divided object-glass. It therefore occurred to him, that by reducing the aperture of the segment through which the brighter star is seen, until both stars are made to appear of equal magnitude, the ratio of light would be inversely as that of the squares of the diameters of the apertures. He afterwards found that this method had been recommended by Bouguer in the middle of the last century, and that it had been subsequently applied by several observers, including among others the Rev. W. R. Dawes, with whose researches he became acquainted some time after he had been engaged in the inquiry.

The plan pursued was very simple. A number of semicircles of card-board or stiff paper were prepared, having the same exterior diameter as the object-glass, with concentric apertures diminishing by $\frac{1}{4}$ of an inch from seven inches to half an inch. These fitting into the frame of the object-glass, were kept in place by knee-springs.

The objects under comparison having been brought into the field, the segment through which the bright star was seen, was reduced until its light was equalised to that of the smaller one. In the course of observations of this kind, Mr. Johnson found it necessary to institute a series of delicate experiments with the view of determining whether the two half object-glasses possessed equal facilities of transmitting light, and whether this was true for every part of the same segment.

It remained to compare the photometric results obtained in this manner with the magnitudes estimated with the meridian instruments, and with the corresponding estimates of other observers. This comparison is exhibited in a series of tables which Mr. Johnson has appended as the results of his researches.

Table I. contains observations to determine the scale of magnitudes used in the Radcliffe observations. The stars compared together range from the fourth to the ninth magnitude, but generally there is a preponderance of small stars. The mean ratio of the diminution of light, corresponding to an interval of a whole magnitude, was found by him to be 0·424. The mean error of a single comparison was 0·057, and as there were sixty of such comparisons, the mean error of the final result was 0·007.

Table II. contains the results of some experiments to test the accuracy of the ratio 0·424, when applied to stars of a higher class than those from which the ratio was mainly deduced: it also exhibits a comparison between the photometric magnitudes due to this ratio, and the estimated magnitudes of other observers.

From certain experiments made by Sir John Herschel on the relative brightness of the larger stars, Mr. Johnson found that the ratio of the light of a star of the first magnitude to one of the sixth magnitude is as 112 : 1. This indicates a diminishing ratio of

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0·407, a result which agrees very nearly with the ratio which Mr. Johnson had deduced from his own estimated magnitudes.

Mr. Johnson also found that for stars from the first to the sixth magnitude, the numbers assigned by the photometric ratio 0·424 his presented a striking agreement with those given by M. Struve in *Catalogus Novus*, p. xxxv., and *Mensur. Microm.* p. lxviii., which was deduced entirely from considerations founded on the relative number of stars of each class, and on their equal distribution throughout space.

"Argelander and Groombridge," says Mr. Johnson, "apparently guided by similar considerations, both arrived at nearly the same *ideal* standards as ourselves, as the following comparisons will show. Our object-glasses, it will be remembered, are four inches in diameter, and we note to (10); Argelander's is 4·25 inches, and he noted also to (10); Groombridge's object-glass was 3·5 inches, and he did not go lower than the (9) magnitude.

Radcliffe Obs.	Groombridge.	No. of Comps.	Mean Error of One Comp.	Argelander.	No. of Comps.	Mean Error of One Comp.
3·0	2·8	11	±0·30	2·6	11	±0·45
4·0	3·9	20	·29	3·9	20	·32
5·0	5·0	20	·35	5·1	20	·25
6·0	6·1	20	·32	6·1	20	·30
7·0	7·0	40	·38	7·2	63	·38
8·0	7·9	40	·41	8·2	54	·39
9·0	8·9	40	±0·40	9·2	40	±0·37

From twelve photometric comparisons, Mr. Johnson deduced the ratio of diminution of light corresponding to a whole magnitude in Groombridge's scale to be 0·388, with a mean error of ±0·029; and from twenty such comparisons he found the ratio of diminution in Argelander's scale to be 0·431, with a mean error of ±0·015.

It is a remarkable fact that Mr. Dawes, by adopting a ratio of diminution equal to 0·25, obtained a series of magnitudes which appeared to him to present a satisfactory agreement with the estimated magnitudes of Argelander, although the latter have been found to correspond very nearly with those of Mr. Johnson, which proceeds according to a different ratio from that assumed by Mr. Dawes. Mr. Johnson has suggested an explanation of this discordance, in which, however, it will be seen that Mr. Dawes does not concur.

Table III. contains some observations made for the purpose of determining Struve's scale in his *Mensuræ Micrometricæ.* From a series of comparisons between the estimated magnitudes of Struve and his own photometric results, Mr. Johnson deduced the mean ratio of diminution of light to be 0·348, the mean error of a single comparison being ±0·036, and that of the entire result ±0·007. This result, however, he found to be true only for stars above the 6·7 magnitude. For smaller stars, M. Struve appears to have adopted a ratio which Mr. Johnson found on the whole to present a satisfactory agreement with his own, viz. 0·424.

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It would seem also that Sir John Herschel, in his observation of double stars, recorded in the *Memoirs* of the Astronomical Society, adopted a different scale for stars above and below the sixth magnitude. Assuming the ratio of diminution to be 0·480 for the former class of stars, and 0·357 for the latter, Mr. Johnson showed that the estimated magnitudes would be represented with tolerable accuracy. It is worthy of remark that in this case the transition is from a higher to a lower ratio, whereas the contrary appears to hold good in the case of Struve's observations.

"As a concluding remark to this part of my subject," says Mr. Johnson, "I will recall the reader's attention to the fact that, in the course of the discussion, the law of diminution has been deduced from *five* different authorities, and another result from Otto Struve is given at p. 45. All these observers acted quite independently of each other, and though their instruments varied from the $3\frac{1}{2}$ to the 15-inch refractor and 18-inch reflector, yet their determinations, notwithstanding many and great individual anomalies, present a general appearance of consistency and agreement which can hardly be accidental.

"The several results are as follows:—Sir John Herschel's being that which was deduced from the light of *Sirius;* Struve's, his mean ratio from (1) to (12), which is his own limit; if we had taken (13), his value would become ·415, and the agreement would be more perfect.

Herschel	0·407	Weight	1
Struve	0·383		2
Otto Struve	0·406		1
Argelander	0·431		3
Groombridge	0·388		1·5
Radcliffe Observatory.........	0·424		4

"Allowing the annexed weights to the respective results, the mean is 0·412, with a mean error of ±0·0065; and I have reason to believe that with a very slight modification this law will be found to hold good from *Arcturus*, taking Sir John Herschel's estimate of that star on his vulgar scale, through the intermediate stages to the (9) magnitude on Argelander's or our own."

Table IV. contains observations for the purpose of determining the variation of light of δ *Cephei.*

Mr. Johnson's observations of this star were made in the months of August and September 1851. They indicate the period of variation to be $5^{d}\ 6^{h}\ 36^{m}\ 20^{s}{\cdot}4$. By combining his own observations with Argelander's minimum of 1840, Nov. 1·503, he found the period to be $5^{d}\ 6^{h}\ 42^{m}\ 18^{s}{\cdot}4$.

Mr. Johnson concludes the account of his labours by pointing out the class of objects to which the heliometer is more especially adapted as an instrument of photometrical research. "The costliness of the instrument," he remarks, "will probably suggest an argument against its use. But this need not be an impediment. A half

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object-glass of 4 inches will penetrate to a (10), which is only one magnitude higher than half of 7·5 inches will reach; and the instrument itself would be very much more convenient. A very ordinary equatoreal mounting would suffice, and no great expense need be incurred in its other fittings. Indeed, I am not sure if it would not be better to return to Bouguer's original construction, and employ two entire object-glasses of smaller dimensions. This, I imagine, would be a still more economical arrangement."

"It is a subject which may be taken up at any time: it does not require continuous exertion; it involves no tedious calculations. For these reasons it is well suited to amateurs, to whom, if I mistake not, a rich and interesting field is open, which professional observers, from the extent of their avocations, will be unable to enter."

Report addressed by the Astronomer Royal for Scotland to the Board of Visitors, at their Visitation of the Royal Observatory, Edinburgh, November 1852.

It will be seen from this report that Professor Piazzi Smyth has finally completed the reduction and printing of his predecessor's observations, and that he has already made considerable progress in preparing for the press his own observations of the years 1849–50–51. The class of objects, which has recently occupied his attention, has been already alluded to in the last Annual Report of the Society.

Steps have been taken for forming a galvanic connexion between the Observatory and the Railway Station at the Waverley Bridge. As soon as this shall be effected, the Observatory will be enabled to maintain an unbroken galvanic communication with the Royal Observatory of Greenwich, a circumstance which cannot fail to be attended with important advantages.

Professor Smyth remarks that the bright twilight which prevails during the summer months in high northern latitudes, and the generally cloudy state of the atmosphere, have proved very unfavourable to accurate observation, during the period when his duties in connexion with the University allow him most leisure for the prosecution of his labours at the Observatory. He proposes, therefore, that an arrangement should be made, enabling the Director to proceed annually with an equatoreal to some elevated region in a southern latitude, where he might execute a series of measures at a *temporary* observing station during the summer months; which measures in the autumn would be brought home, computed, and printed with all the resources of a civilised country, the results forming part of the usual Observatory Volume. He points out the peculiar advantages which the Peak of Teneriffe affords for this purpose. "As to the instrument itself," he adds, "I have devised a new construction of the equatoreal stand, which will allow of its being taken to pieces, and transported with great facility."